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(54) Wellhead Connection Apparatus

(57) A subsea production tree (26) has a plurality of downwardly extending tubular subs (30) which mate with corresponding openings in a tubing hanger receptacle (34). The tubular subs have an outside diameter throughout a short portion of the inserted length greater than the inside diameter of the corresponding opening, whereby an interfering metal-to-metal seal is effected.

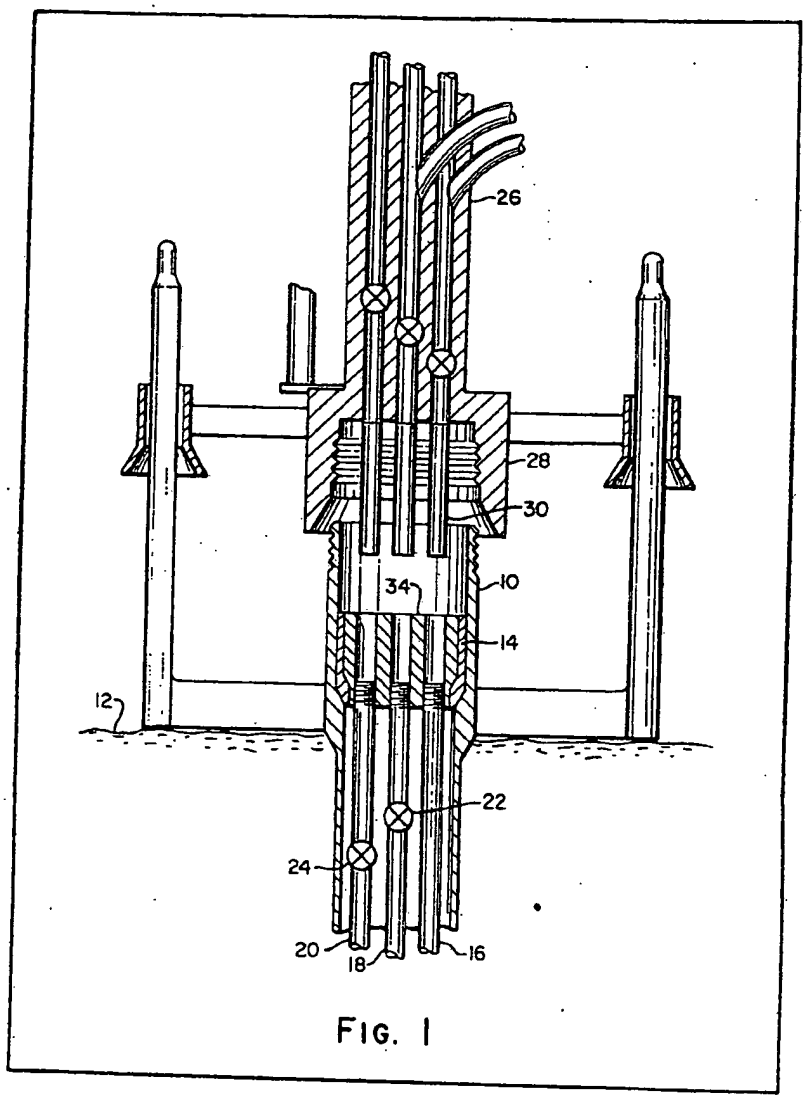

FIG. 1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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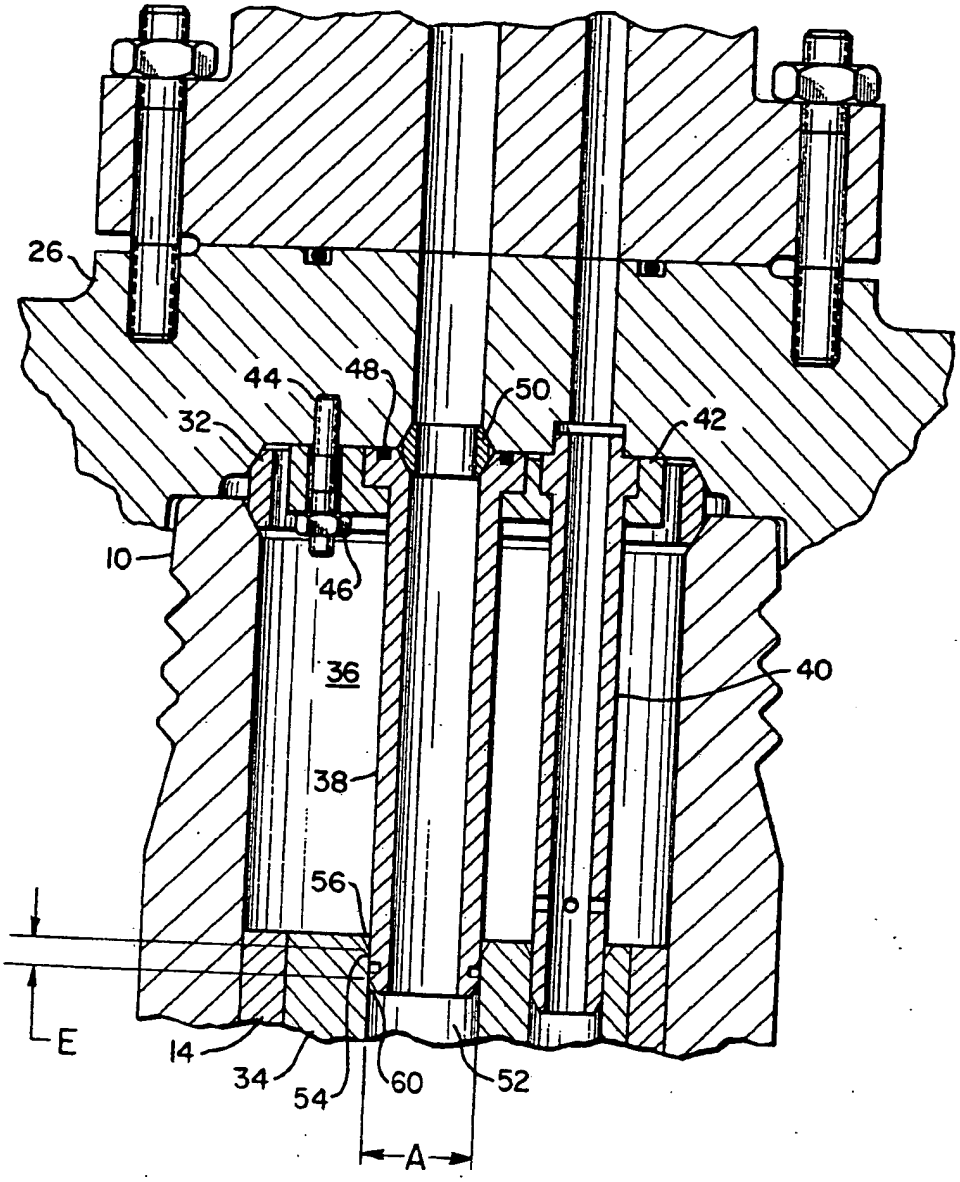

FIG. 2

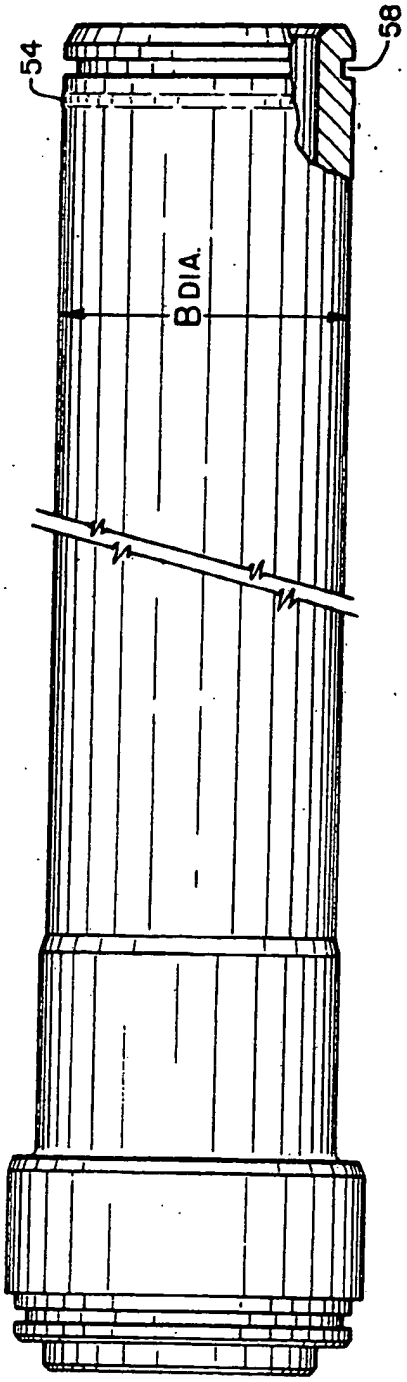

FIG. 4

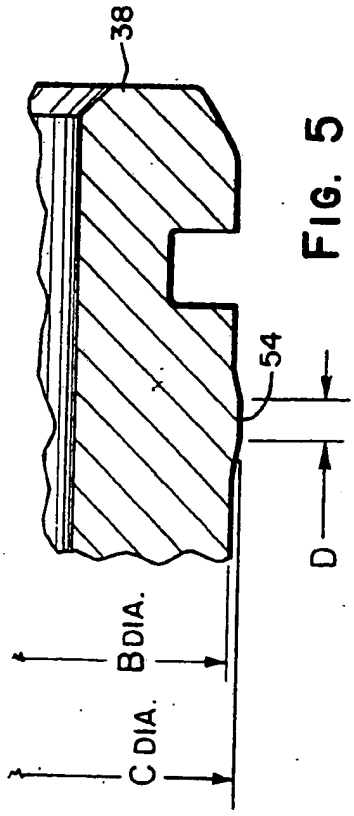

FIG. 5

replaceable member. The tubular sub may be of annealed steel, and the receptacle of hardened steel. It is also preferred that the interference be not less than 0.00254 cm. nor more than 0.0254 cm. The length of the overdiameter portion is preferably between 0.127 cm. and 0.508 cm. long. A dry lubricant on the tubular sub in the area where the outside diameter is greater than the inside diameter of its respective opening increases the reliability of the system.

An embodiment of the invention is hereinafter described, by way of example, with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a general arrangement showing the location of the production tree with respect to the wellhead system;

Figure 2 is a sectional elevation of the lower end of the production tree and the upper end of the tubing hanger receptacle which illustrates the stab sub details;

Figure 3 is a sectional plan view looking up through the stab sub;

Figure 4 is a detail view of one of the stab subs; and

Figure 5 is a detail of the interfering portion of the sub.

Best Mode for Carrying Out the Invention

A wellhead 10 is essentially supported from the ocean floor 12. A tubing hanger 14 is supported within the wellhead, and the hanger in turn supports a plurality of tubes including annular access tube 16 and production tubes 18 and 20. The production tubes also include downhole safety valves 22 and 24 which are operated by hydraulic lines not shown. The production tree 26 includes a female coupling 28 for connection to the wellhead 10. It also includes a plurality of tubular subs 30 which are arranged to pass within corresponding openings in tubing hanger 14.

Referring to Figure 2 the production tree 26 is attached to the wellhead 10 by a coupling of the type illustrated in U.S. Patent 3,321,217. This essentially clasps the outer notched openings of the wellhead, drawing the tree against the wellhead and energizing internal seal 32. Since the tubing hanger receptacle 34 which forms a portion of tubing hanger 14 is sealed by its support to the wellhead 10, sealed internal volume 36 is established.

Stab subs 38 and 40 are removably attached to the production tree by plate 42 which is bolted to the body of the production tree with studs 44 and nuts 46. Since no motion after initial fabrication is required on the joints between the stab subs and the production tree housing, conventional seals 48 and 50 may be used at this location. In the particular embodiment illustrated, stab sub 40 which connects to the annulus of the well is not sealed and, in fact, has openings therethrough so that the internal pressure of volume 36 is pegged at the pressure of that line.

The tubing hanger receptacle 34 has openings therein which correspond to their various stab subs which are attached to the bottom of the production tree. Stab sub 38 and its corresponding opening 52 will be discussed in detail, while the remaining stab subs and the corresponding openings follow the same general principles.

Figure 4 is a general illustration of the stab sub 38, and Figure 5 is a detail of the interference portion at location 54. The opening in the tubing hanger receptacle 34 has an opening A of a dimension between 9.8425 cm. and 9.85266 cm. The outside diameter of the majority of the stab sub 38 is dimension B which is between 9.7917 cm. and 9.8425 cm. It can be seen that the clearance varies from a minimum of 0 to a maximum of 0.6096 cm. The upper end of opening 52 has a tapered portion 56 to facilitate guidance of the stab sub within the opening.

At location 54 the stab sub has a portion of a diameter C which is between 9.87298 cm. and 9.87806 cm. and which has a length D of 0.254 cm. It can be seen that the interference fit varies between 0.02032 cm. and 0.03556 cm. when the stab sub is inserted within the opening. Groove 58 may be supplied for a backup nonmetallic resilient seal if desired.

The overlap portion E which does not include either the tapered portion 56 of the tubing hanger receptacle, nor the tapered portion 60 of the stab sub, is in the order of one inch. It can be seen that the interference length of 0.245 cm. is a minor portion of the entire overlap. The coextensive length is governed by the tapers on each element which facilitate stabbing entry and longitudinal tolerances which permit the interference fit within the parallel sides of the opening. It should also be sufficient to avoid excessive concern with the maintenance of tolerances throughout the length of the stab sub and through the coupling arrangement between the wellhead and the production tree. The material of the stab sub is fully annealed steel which has a yield strength in the order of 20,000 psi. On the other hand, the steel of the tubing hanger receptacle is hardened steel with a yield strength in the order of 60,000 psi. Accordingly, when the yield strength of the stab sub is exceeded, it is the protrusion on the stab sub which will yield without damaging wear on the more difficult to replace tubing hanger receptacle. Even allowing for some work hardening of the stab sub, the yield strength will stay below that of the receptacle. Accordingly, any maintenance or repair work may be done on a more easily removed stab sub.

While there is no definite breakpoint in the amount of interference, analysis and test have indicated that interference in the order of 0.00254 cm. is required to get sufficient deformation for effective sealing. As the interference increases, with 0.0508 cm. being the recommended maximum value, the possibility of galling of the material increases. Should this occur, grooves will form which will cause a

elongated tubular sub; means for removably connecting the tubular sub in a fluid tight manner to said second tubing line; means for orienting said second tubing line such that the end of the tubular sub passes within the opening of said receptacle, whereby an overlap portion of the tubular sub is established within said receptacle; the tubular sub having an outside diameter less than the inside diameter of its respective opening through a majority of the overlap portion; and the tubular sub having an outside diameter greater than the inside diameter of its respective opening through a minority of the overlap portion.

14. Apparatus as claimed in Claim 13, wherein the portion of the tubular sub having an outside diameter greater than the inside diameter of its respective opening exceeds the inside diameter by more than 0.00254 cm.

15. Apparatus as claimed in Claim 13, wherein the portion of the tubular sub having an outside diameter greater than the inside diameter of its respective opening does not exceed the inside diameter of the opening by more than 0.0508 cm.

16. Apparatus as claimed in Claim 13, wherein the minority of the overlap portion does not exceed 0.508 cm.

17. Aparatus as claimed in Claim 16, wherein the minority of the overlap portion exceeds 0.127 cm.

18. Apparatus as claimed in Claim 17, wherein the outside diameter of the tubular sub which is greater than the inside diameter of its respective opening exceeds the inside diameter by more than 0.00254 cm but not more than 0.0508 cm.

19. Apparatus as claimed in any one of Claims 13, 15, 17 or 18, wherein the portion of the tubular sub having an outside diameter greater than the inside diameter of its respective opening is remote from the end of said tubular sub.

20. Apparatus as claimed in Claim 13 or Claim 18, including a dry lubricant on said tubular sub in the area where the outside diameter is greater than the inside diameter of its respective opening.

21. Apparatus as claimed in Claim 13 or Claim 18, wherein the material of said tubular sub has a yield strength less than the material of said tubing hanger receptacle.

22. Apparatus as claimed in Claim 21, wherein said tubular sub is of annealed steel, and said receptacle is of hardened steel.

23. A subsea tubing connection apparatus substantially as hereinbefore described with reference to the accompanying drawings.

24. A wellhead connection apparatus substantially as hereinbefore described with reference to the accompanying drawings.

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